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Mesoarchean western margin of the Superior Craton in the Lake Winnipeg area, Manitoba[1]

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Abstract: The west-facing Lewis-Storey rift assemblage of arkosic grit, quartzite, komatiite, and iron-formation rests unconformably on ca. 3 Ga basement in eastern Lake Winnipeg. Regional correlations suggest a probable ca. 2.9 Ga age for the sequence, which may mark the Mesoarchean western margin of the North Caribou terrane. The rift package is structurally overlain by the east-facing Black Island assemblage of submarine tholeiitic and calc-alkalic basaltic rocks and the <2.706 Ga arkosic Hole River sequence. Prominent, northwest-trending, dextral D_1 shear zones, thought to be responsible for tectonic juxtaposition of the major tectonostratigraphic assemblages, are overprinted by S_2 crenulations and the D_3 Seymourville shear zone that accommodated 7 km of dextral strike slip. Possible linkages between these tectonic elements and those of the Rice Lake and Wallace Lake belts to the east are being explored through geochemical, geochronological, and structural studies.

Résumé : L'assemblage de rift de Lewis-Storey à vergence ouest se compose d'arène arkosique, de quartzite, de komatiite et de formation de fer et repose en discordance sur le socle d'environ 3 Ga dans la partie orientale du lac Winnipeg. Les corrélations régionales permettent de conclure que l'âge probable de cette séquence est d'environ 2,9 Ga. La séquence pourrait délimiter la bordure occidentale mésoarchéenne du terrane de North Caribou. L'assemblage est recouvert structuralement par l'assemblage de roches basaltiques tholéiitiques et calco-alcalines sous-marines de Black Island, à vergence est, et par la séquence arkosique de Hole River datant de moins de 2,706 Ga. Des zones saillantes de cisaillement dextres D_1, de direction nord-ouest, qui seraient responsables de la juxtaposition tectonique des principaux assemblages tectonostratigraphiques, sont surimprimées par des crénulations S_2 et par la zone de cisaillement D_3 de Seymourville qui renferme un décrochement dextre de 7 km. Des études géochimiques, géochronologiques et structurales permettent d'examiner les liens pouvant exister entre ces éléments tectoniques et ceux des ceintures du lac Rice et du lac Wallace vers l'est.

[1] Contribution to the Western Superior NATMAP Project

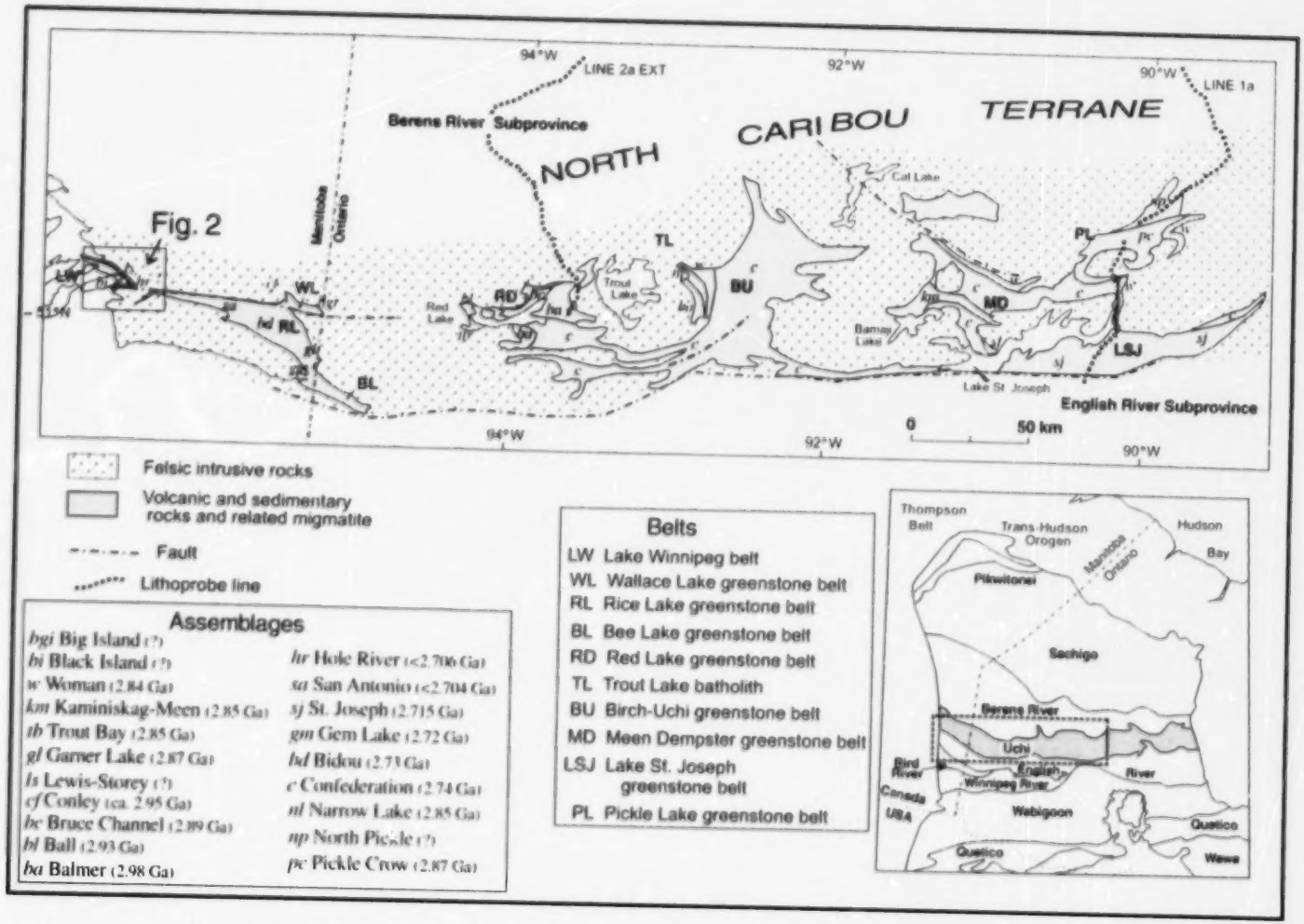

Figure 1. *Tectonic map of the western Uchi Subprovince showing major greenstone belts and assemblages.*

INTRODUCTION

A principal goal of the Western Superior NATMAP Project has been to decipher relationships between blocks of older (Mesoarchean) crust and younger (Neoarchean) volcano-sedimentary sequences. In many areas, contacts are destroyed by younger granitic intrusions, and possible basement–cover relationships must be examined by indirect means such as geochronological, geochemical, or tracer isotopic studies. Over the past two years, investigations have focused on the southern flank of the ca. 3.0 Ga North Caribou terrane (Thurston et al., 1991), one of the largest blocks of Mesoarchean crust in the Superior Province, and the adjacent Uchi Subprovince.

As defined, the North Caribou terrane consists of tonalitic basement and an inferred unconformable platform/rift succession of quartzite, carbonate, iron-formation, and komatiite (Thurston et al., 1991). Although common along the northern margin, such sequences have been documented along the southern flank only at Wallace Lake (Sasseville and Tomlinson, 2000), and are bracketed between 3.0 and 2.92 Ga (Poulsen et al., 1996). Two additional occurrences of rift sequences, the Lewis-Storey and North Wanipigow assemblages, are described in this contribution. Also illustrated are 1) the well exposed unconformity between 3.0 Ga tonalitic basement and the overlying Lewis-Storey rift assemblage; and 2) features associated with the tectonic contact between this westward-younging Mesoarchean sequence and the eastward-younging tholeiitic and calc-alkalic volcanic rocks of the Black Island assemblage.

GEOLOGICAL SETTING

Old crust was recognized in the Lake Winnipeg area during the pioneering geochronological study of Krogh et al. (1974) that identified 3.0 Ga tonalite and 2.9 Ga gneiss, and inferred a pre-2.7 Ga regional deformation–metamorphic event. Similar Mesoarchean ages were documented subsequently to the east, in the English Lake magmatic complex (3.003 Ga; Turek and Weber, 1994) and in detrital zircon populations from sandstone and conglomerate of the Conley assemblage at Wallace Lake (Poulsen et al., 1996). To the north, the core of the North Caribou terrane is dominated by Neoarchean (2.745–2.69 Ga) plutons of the Berens River plutonic complex (Fig. 1; Corfu and Stone, 1998; Stone, 1998).

In eastern Manitoba, the North Caribou terrane is separated from Neoarchean volcano-sedimentary rocks of the Rice Lake belt by the Wanipigow Fault (Fig. 2). This structure truncates units including the 2733 to 2729 Ma Bidou Lake subgroup and <2704 Ma (V. McNicoll and J. Percival, unpub. data, 2000) San Antonio Formation (Fig. 1). In the eastern Lake Winnipeg area, structures strike dominantly northwest (Brown, 1981). A regional unconformity marks the western limit of 3.0 Ga basement and is overlain by a thin rift sequence. These units young westward toward the adjacent eastward-younging basaltic Black Island assemblage, requiring a major tectonic break. The <2.706 Ga Hole River sedimentary sequence shares the D_1 and younger deformation events with the older North Caribou terrane and Black Island assemblage, suggesting that the three were assembled during D_1 and subsequently shared a common history.

EAST SHORE PLUTONIC COMPLEX

The East Shore Plutonic Complex (Fig. 2) contains a 1 to 2 km wide, linear body of homogeneous hornblende-biotite tonalite that underlies the east shore of Lake Winnipeg and eastern islands. It grades to the east into a layered complex of tonalite, quartz diorite, and diorite, with sheets of gabbro, pyroxenite, and hornblendite. All units carry a moderate to strong northwest-striking S_1 foliation, with intense deformation in D_1 shear zones. A pre-D_1/ S_1 foliation is evident in a few outcrops.

The hornblende tonalite is coarse to medium grained, with characteristic blue quartz and plagioclase phenocrysts up to 1 cm in diameter. Where primary features are preserved, the rock is equigranular to plagioclase porphyritic, with 10% to 15% biotite and 5% to 10% hornblende. Shear bands are well developed along with sporadic C-S fabrics in D_1 greenschist-facies shear zones, characterized by pervasive alteration of hornblende and biotite to chlorite (Fig. 3). Relics of an older (pre-D_1), east-trending foliation are preserved locally in tonalite.

Enclaves of sandstone and gneiss were observed within the hornblende tonalite at two localities in the Rice River Bay area (Fig. 2), and may represent remnants of an ancient supracrustal sequence (Ermanovics, 1970). At the first locality, tonalite contains lenticular enclaves (2 m by 20 cm scale) of fine-grained, schistose sandstone with a strong east-west foliation that is transected by D_1 chlorite-bearing shear zones. At the second locality, S_1-foliated quartz diorite hosts a 1 m by 2 m enclave of migmatitic, porphyroclastic gneiss (Fig. 4) in which pre-D_1 folds of the mylonitic layering are truncated at the enclave margin. These rare examples of older structures provide evidence of a significant geological history predating emplacement of the East Shore Plutonic Complex.

The layered complex east of the tonalite consists chiefly of hornblende-biotite quartz diorite, with 1 to 20 m scale sheets of more mafic composition. Blue quartz (<10%) characterizes the homogeneous, medium-grained quartz diorite, which contains 10% to 20% biotite and 15% to 25% hornblende. High-strain (D_1) zones in the layered complex generally form in quartz diorite and diorite units, where deformation features range from broad (about 100 m wide) zones of flaser to augen foliation at lower strain levels, to narrow (1–10 m) protomylonite and mylonite zones at higher strains. Gabbro, pyroxenite, and hornblendite generally preserve coarse igneous textures.

The hornblende tonalite is thought to correspond to 3.00 Ga tonalite dated by Krogh et al. (1974) and Turek and Weber (1994). An age of ca. 2.9 Ga on the layered complex (Krogh et al., 1974) may reflect Neoarchean deformation and metamorphism.

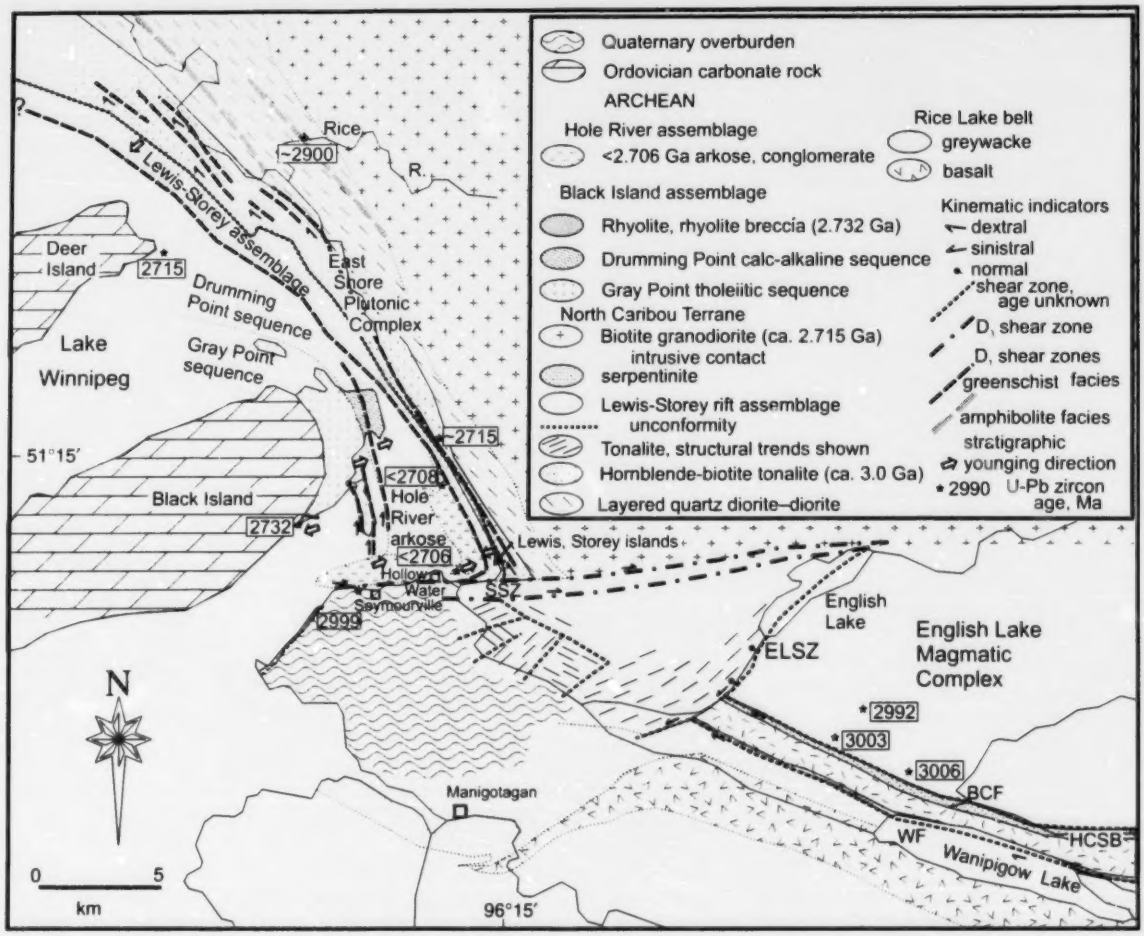

Figure 2. *Tectonic map of the eastern Lake Winnipeg– Wanipigow Lake area (modified from Ermanovics, 1981; Weber, 1991). Many small islands in eastern Lake Winnipeg are not shown at this scale. BCF = Beaver Creek Fault; ELSZ = English Lake shear zone; HCSB = Hay Creek serpentinite belt; SSZ = Seymourville shear zone; WF = Wanipigow Fault.*

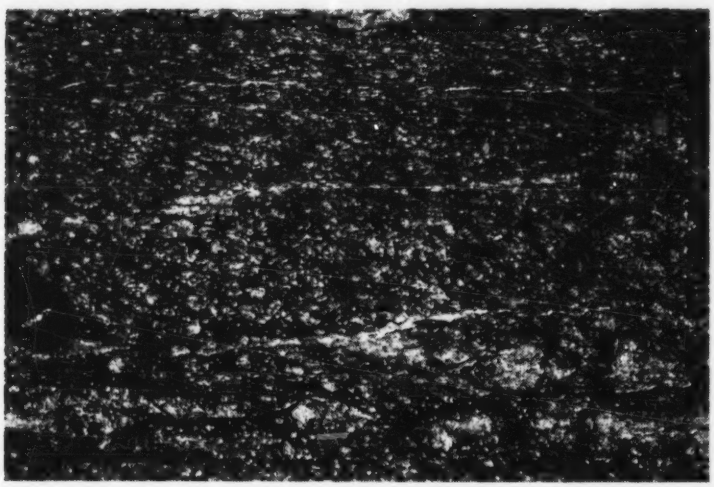

Figure 3.

Dextral D_1 shear bands developed in tonalite, East Shore Plutonic Complex.

Figure 4. *Porphyroclastic gneiss enclave in weakly S_1-foliated hornblende-biotite quartz diorite, East Shore Plutonic Complex.*

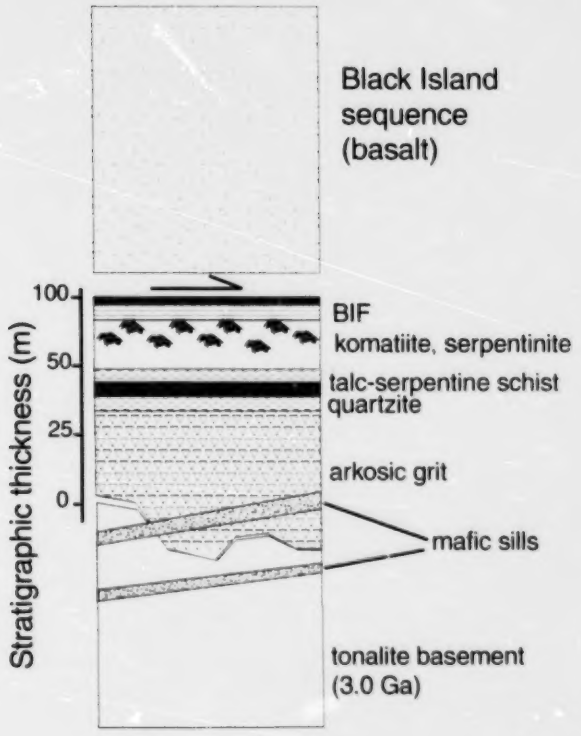

Figure 5. *Composite stratigraphic column showing major units of the Lewis-Storey assemblage.*

POSSIBLE >2.9 GA SUPRACRUSTAL SEQUENCES

Rift-related sedimentary and volcanic rocks occur in the Lewis-Storey assemblage on eastern Lake Winnipeg and the North Wanipigow assemblage near Wanipigow Lake. These rocks are similar to a <3.0 to >2.92 Ga package of quartzite, iron-formation, and komatiite at Wallace Lake (Fig. 1; Poulsen et al., 1996; Sasseville and Tomlinson, 2000; V. McNicoll, unpub. data, 2000).

Lewis-Storey assemblage

The Lewis-Storey assemblage is a west-younging sedimentary–volcanic sequence that unconformably overlies tonalitic basement along the eastern side of Lake Winnipeg. Poorly exposed iron-formation and ultramafic rocks, seen only on Lewis and Storey islands (Fig. 2), may be responsible for a prominent, positive aeromagnetic anomaly that extends over 50 km to the north-northwest beneath the waters of Lake Winnipeg.

At six low-strain localities over 30 km of strike length, the western margin of the tonalite was observed to be truncated by an unconformity and overlain by a unit of massive to thick-bedded grit consisting of angular quartz and plagioclase detritus with up to 10% chloritic matrix (Fig. 5, 6). Near the base of this 15 to 40 m thick, generally unsorted arkosic grit are local angular pebbles and cobbles of the basement hornblende-bearing tonalite (Fig. 7). Thinly laminated, fine-grained quartzite, including fuchsite-bearing beds (Fig. 8), forms units up to a few metres thick, in association with muscovite-rich schist, aluminosilicate-bearing schist, and talc schist. An exposure gap separates these sedimentary rocks from komatiite with clinopyroxene spinifex exposed on Lewis Island (*see* Percival and Whalen, 2000, Fig. 5). Iron-formation on Storey Island, surrounded by serpentinite and talc schist, consists of millimetric to centimetric layers of carbonate, chert, magnetite, and sericite schist.

Sills of mafic and rare felsic composition cut the sedimentary–volcanic sequence. In one location, a 1.5 m thick quartz-feldspar porphyry occurs in arkosic grit within a few metres of the basal unconformity. The body contains an internal aphyric breccia zone, suggestive of high-level intrusion into a wet sedimentary host. Mafic sills up to 15 m thick intrude both the East Shore Plutonic Complex and the

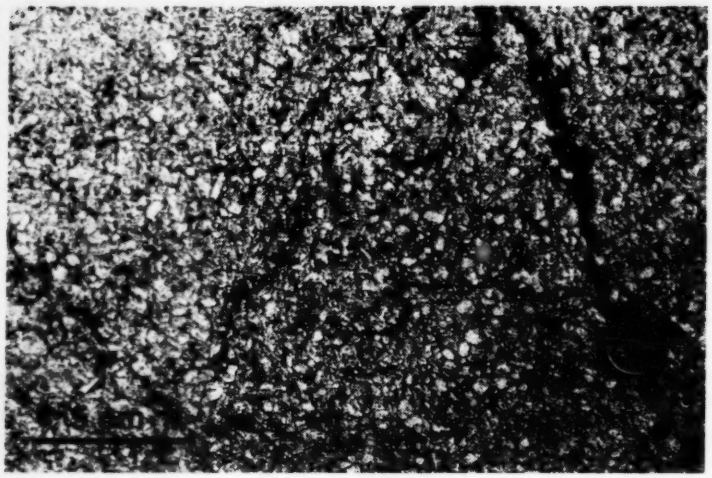

Figure 6.

Arkosic grit of the Lewis-Storey assemblage showing angular quartz and plagioclase granules.

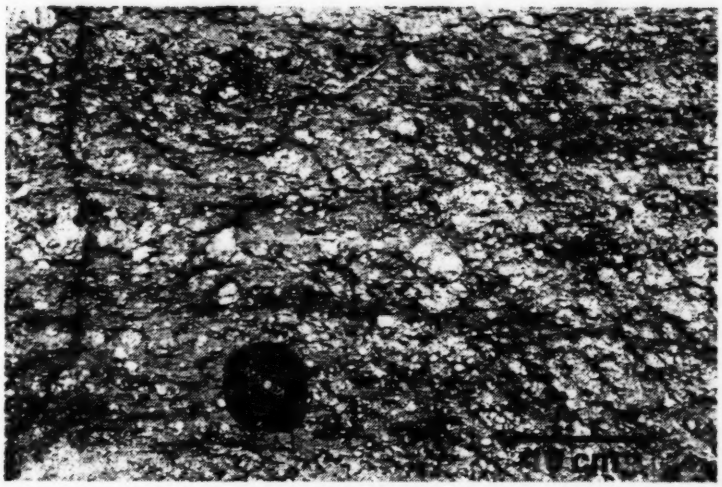

Figure 7.

Basal conglomeratic grit containing angular tonalite clasts in a chloritic matrix.

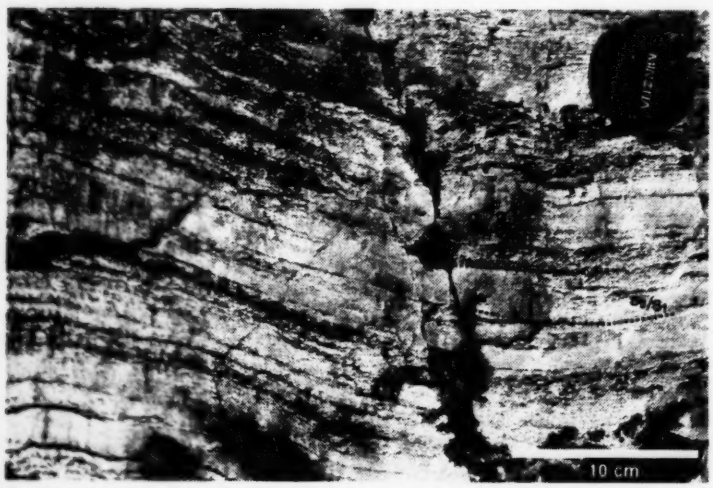

Figure 8.

Fuchsitic quartzite of the Lewis-Storey assemblage. Northwest-trending bedding (S_0) is accentuated by bedding-parallel S_1. Note open, southwest-trending F_2 folds.

Lewis-Storey assemblage within a few hundred metres of the unconformity. They are generally fine- to medium-grained diabasic gabbro with chilled margins up to 50 cm wide.

The sedimentary–volcanic (komatiite) sequence and associated mafic to felsic sills are interpreted to mark an ancient (ca. 2.9 Ga) rifted margin of the North Caribou terrane. Basal grit may have developed through chemical weathering and slight downslope transport of weathered tonalitic basement exposed as a result of rift-related uplift (cf. Rainbird and Ernst, in press). Deposition of quartzite and carbonate-bearing iron-formation may reflect shallow-water deposition as a result of thermal subsidence following initial rifting. The presence of komatiite in the stratigraphic record supports a model of plume-driven rifting (cf. Tomlinson et al., 1998).

North Wanipigow assemblage

A poorly preserved sedimentary–volcanic sequence lies along the southern margin of an east-trending body of hornblende-biotite tonalite in the Wanipigow River area (Fig. 2). Both the tonalite and supracrustal rocks resemble those in the eastern Lake Winnipeg area, although no unconformity was observed. The tonalite is bordered to the south by a chloritic grit unit up to 10 m thick (Fig. 9) and is overlain by fine-grained, thinly laminated siliceous siltstone. Local magnetite-chert and hematite-chert ironstone is also present at this structural level. Gabbroic sills with minor serpentinite schist layers occur structurally above the iron-formation, as well as within the tonalite. These units are moderately to highly strained, and are separated by the dextral Wanipigow Fault from a metagreywacke unit to the south (Weber, 1991).

BLACK ISLAND ASSEMBLAGE

The Black Island assemblage consists of lower greenschist-facies volcanic and volcaniclastic rocks that form a >3 km thick, steeply dipping, northeast-younging sequence (Bailes and Percival, 2000a). The lower third of the section consists of basalt and basaltic andesite flows of the Gray Point sequence (Bailes and Percival, 2000b), whereas the overlying Drumming Point sequence comprises andesitic flows and associated volcaniclastic rocks.

Gray Point sequence

A basal, >1000 m thick unit of aphyric, nonvesicular, pillow basalt and basaltic andesite flows with minor interpillow hyaloclastite is overlain by 700 to 1200 m of massive, porphyritic basalt and basaltic andesite flows that are locally separated by <3 m thick units of chert. Most of the porphyritic flows are pyroxene- and pyroxene-plagioclase-phyric, and thicker flows are locally gabbroic textured.

Gray Point basalt and basaltic andesite plot in the field of modern ocean floor basalts on a diagram of Cr versus Ti and in the normalized mid-ocean-ridge basalt (N-MORB) field using Th, Zr, and Nb. Primitive mantle-normalized multi-element plots show slightly depleted light rare-earth elements (LREE), Th, and Nb, resembling modern N-MORB compositions.

Drumming Point sequence

The base of the Drumming Point sequence is marked by an 80 to 120 m thick unit of bedded, intermediate volcaniclastic rocks with minor chert, siliceous sedimentary rocks, and polymictic conglomerate. Volcaniclastic rocks consist of 10 to 100 cm thick beds displaying grading, scours, and partial Bouma sequences. Intercalated with the volcaniclastic turbidite are beds of conglomerate and breccia containing rounded clasts of rhyolite and dacite, rock types not present in either the underlying or overlying volcanic sequences. The presence of the volcaniclastic sequence at the contact between the MORB-like Gray Point and calc-alkalic Drumming Point sequences suggests that the base of the unit may be a disconformity. Dykes of unfoliated basalt resembling Drumming Point volcanic rocks cut foliated (pre-D_1) basalt on Gray Point (Bailes and Percival, 2000a, Fig. GS-26-7c), which is consistent with this interpretation.

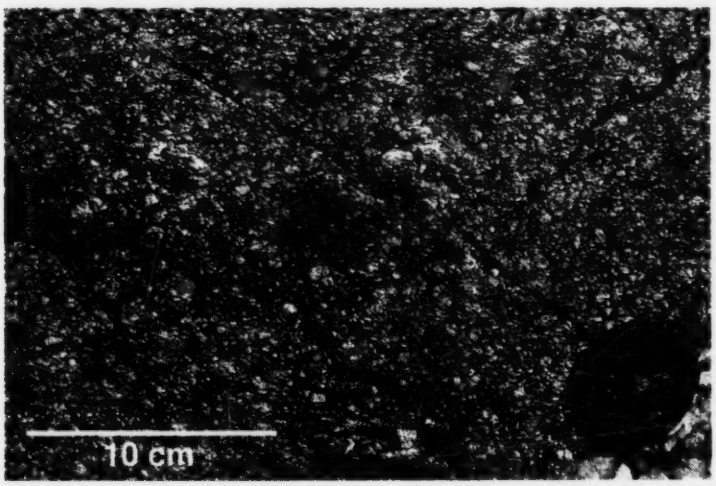

Figure 9.

Arkosic grit forming the basal layer of the North Wanipigow assemblage, Wanipigow Lake.

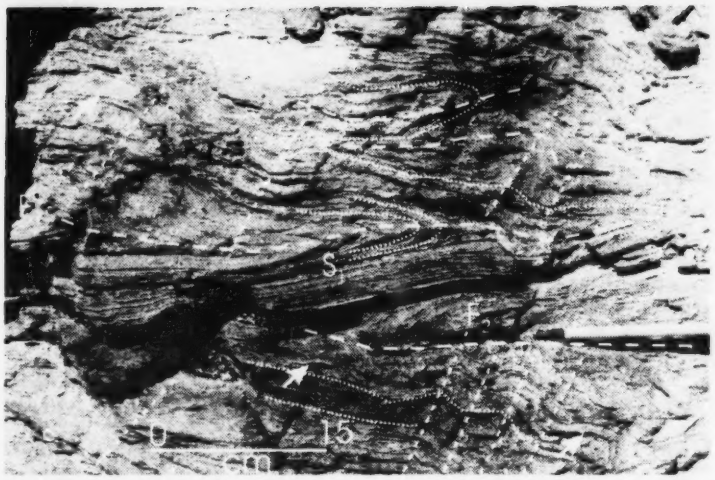

Figure 10.

Stretched-pebble conglomerate (flattened clasts indicated by arrows) of the Hole River sequence, showing a strong S_1 tectonic lamination, tight F_1 Z-fold, and open F_2 crenulations.

The volcaniclastic unit is overlain by a 350 to 1100 m thick sequence of aphyric to plagioclase-phyric, pillowed to massive basaltic andesite and andesite flows. The flows contain rare amygdales, radial pipe vesicles, and synvolcanic dykes. Quartz diorite to gabbro sills occur within the northern Drumming Point sequence and have geochemical features similar to those of the volcanic rocks. Chilled margins and rare quartz amygdales in some bodies suggest intrusion at shallow levels and a possible synvolcanic relationship to the surrounding andesite. Quartz diorite provided a U-Pb zircon age of 2715 ± 10 Ma (Krogh et al., 1974). The Drumming Point sequence is capped by up to 1000 m of feldspathic wacke and associated siltstone, chert, and mafic mudstone.

Rhyolite tuff, breccia, and conglomerate are exposed in a single outcrop on the south shore of Black Island (Fig. 2). A 2732 ± 10 Ma U-Pb zircon age for this unit (Ermanovics and Wanless, 1983) forms the basis of a correlation between the Black Island assemblage and the ca. 2730 Ma Bidou Lake Subgroup of the Rice Lake belt. However, the rhyolite is in fault contact and has a younging direction opposite to that of the main Black Island assemblage (Fig. 2), leaving the latter undated.

Drumming Point basaltic andesite and andesite fall in the arc field on a Th-Zr-Nb plot. On multi-element primitive-mantle-normalized plots, the Drumming Point sequence displays negative Nb relative to Th, La, and Ce, a feature typical of modern subduction-related volcanic rocks.

Figure 11. *Large-scale dextral shear bands in the layered sequence of the East Shore Plutonic Complex. Note boudinaged mafic sills.*

HOLE RIVER SEQUENCE

This arkosic package outcrops on islands in the south central part of the area and comprises north-south and east-west segments (Fig. 2). It consists mainly of indistinctly bedded arkose, with local conglomerate. Well rounded clasts include a variety of plutonic and volcanic rocks, and vein quartz. Primary structures, including graded bedding, pebble lags, scours, and trough crossbedding, suggest that these rocks were likely deposited in a subaerial–fluvial environment. Although northward-younging indicators are common in the less deformed east-west segment, the presence of up to three generations of folds and foliations in some outcrops precludes a simple stratigraphic interpretation. For example,

conglomerate containing rounded cobbles of tonalite and leucocratic granite carries a penetrative S_1 tectonic lamination, folded by tight, northwest-plunging F_1 Z-folds and open, southwest-plunging F_2 warps (Fig. 10).

Two Hole River arkose yielded a range of detrital zircon ages between 3.02 and 2.706 Ga, with peaks at 2.96, 2.85, 2.80, and 2.74 to 2.71 Ga (V. McNicoll and J. Percival, unpub. data, 2000). In conjunction with its sedimentological features, the <2.706 Ga depositional age suggests a late, mainly postvolcanic (Timiskaming-type) setting.

REGIONAL DEFORMATION HISTORY

Rocks in the eastern Lake Winnipeg area contain fabrics that record three regional deformation events (D_1, D_2, D_3). Local evidence of pre-D_1 deformation exists in the East Shore Plutonic Complex and Gray Point sequence (*see* above).

Deformation D_1

The D_1 strain is evident in all units of the map area and generally increases in intensity from north to south and with proximity to the arcuate contact between the East Shore Plutonic Complex and the Black Island assemblage. Strike direction varies from northwest in the north to north-northwest in the south, with consistent steep southwest dips. In the East Shore Plutonic Complex, S_1 is parallel to lithological contacts. In tonalite, strain intensity varies from weak mineral alignment without associated linear fabric elements, to high-strain zones with a prominent, gently south-plunging rodding lineation, dynamically recrystallized at greenschist-facies conditions. The latter zones range up to 8 m in width and affect both tonalite and mafic sills. Evidence of shear strain is common in tonalite, where chloritic folia form shear bands (Fig. 3). These structures indicate mainly dextral shear.

In the layered sequence of the East Shore Plutonic Complex, north-northwest-trending, up to 100 m wide, D_1 ductile deformation zones parallel lithological contacts. Shallow, south-plunging rodding lineations are common, particularly in protomylonitic and mylonitic zones. Kinematic indicators include asymmetric and back-rotated boudins, as well as macroscopic shear bands (Fig. 11). The mylonitic rocks, which are particularly common along the eastern margin of the complex, are cut by sheets of granodiorite.

A penetrative S_1 foliation is evident in sedimentary units of the Lewis-Storey assemblage, and in ultramafic schist derived from komatiitic rocks. Arkosic grit commonly contains shear bands indicating dextral shear.

North-northwest-striking D_1 high-strain zones up to 20 m wide dissect units of the Black Island assemblage, separated by weakly foliated zones that retain primary structures. Most zones occur within lithological units, rather than at major contacts. At low strain levels, the shear-zone foliation in mafic rocks is defined by mineral alignment and attenuated pillow selvages. At high strains levels, mafic rocks become laminated (at a millimetric scale) carbonate-chlorite-quartz schist (Fig. 12).

A discrete D_2 deformation event, which was previously inferred from observed folds of S_1 layering (e.g. Percival and Whalen, 2000, Fig. 6), has been shown by further work this summer to be a late manifestation (F_1) of the D_1 event. These F_1 folds are localized in thinly laminated rocks, including D_1 shear zones, particularly in the carbonate-chlorite schist. Both volcanic rocks of the Black Island assemblage and deformed sills of the Lewis-Storey assemblage exhibit these structures. The F_1 folds plunge moderately to the northwest, are tight to isoclinal, have a consistent 'Z' asymmetry, and generally have no associated axial planar foliation. Although the F_1 folds affect S_1 tectonic layering, they are transected in some exposures by internal dextral shear zones that merge with the S_1 fabric encasing the fold (Fig. 13). The Z-folds are spatially associated and kinematically compatible with the dextral shear zones and are therefore interpreted to have formed by a progressive deformation (D_1) responsible for the shear zones.

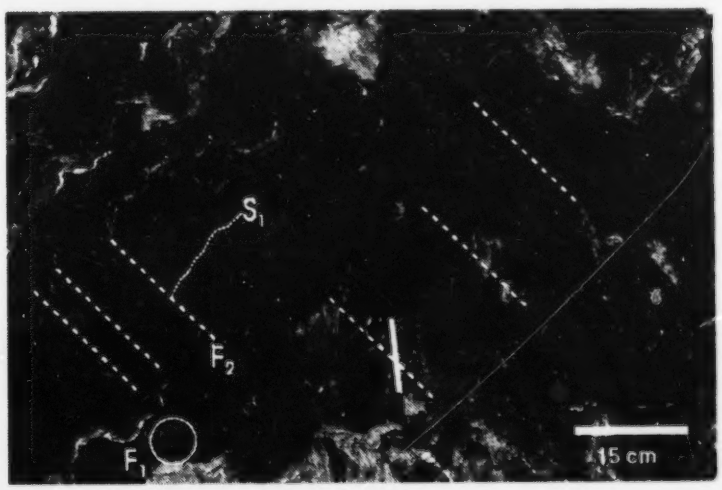

Figure 12.

Chlorite-carbonate-quartz schist developed in D_1 shear zone in Black Island basalt. Note minor F_1 fold in the lower left corner and F_2 crenulations.

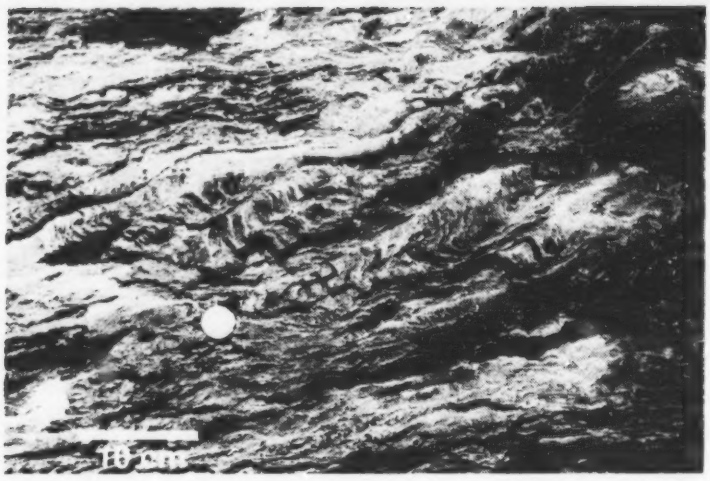

Figure 13.

F_1 Z-fold transected by S_1 foliation, suggesting fold development during progressive D_1 deformation.

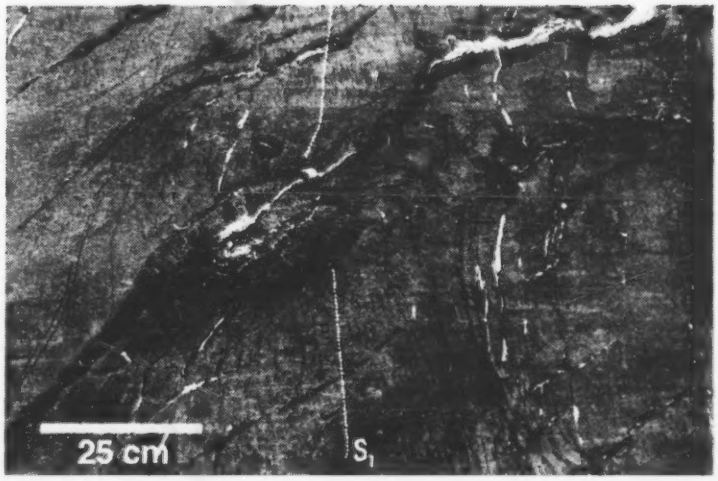

Figure 14.

Tourmaline-quartz- carbonate vein cutting S_1-foliated mafic sill, Lewis-Storey assemblage. Note tourmaline replacement along S_1 planes.

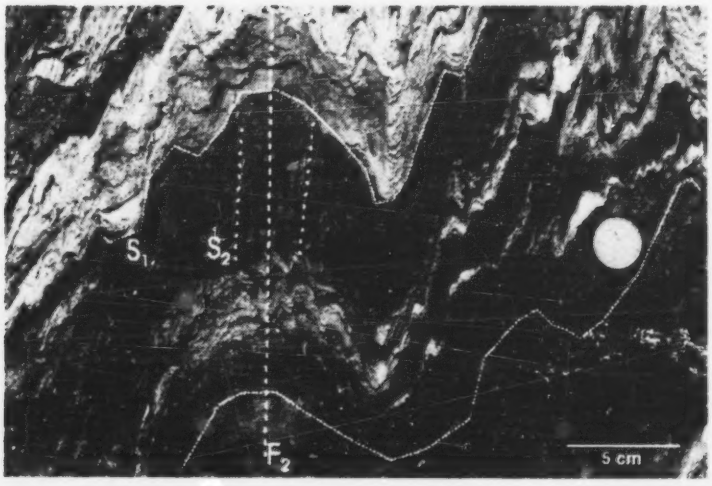

Figure 15.

F_2 folds and associated axial plane S_2 cleavage affecting strong S_1 fabric. The dark and light layers can be traced into pillow cores and selvages respectively, in weakly foliated pillow basalt.

Some parts of the Hole River sequence also contain prominent D_1 fabrics. In arkose of the north-striking segment, a strong, penetrative, bedding-parallel foliation and associated gently south-plunging rodding lineations (L_1) indicate high D_1 strain, as does a fine-scale S_1 tectonic lamination developed in conglomerate (Fig. 10). In contrast, S_1 is weak or absent in the east-trending segment of the Hole River sequence, where folds of well preserved bedding are accompanied by an east-trending S_3 axial plane foliation. Only locally is a weak bedding-parallel foliation present. This segment lies in the on-strike projection of the north-trending D_1 shear zones to the north (Fig. 2), posing a geometrical problem if D_1 postdates the entire Hole River sequence. Sedimentary rocks of the Hole River sequence may have been deposited during D_1 deformation, possibly in strike-slip basins.

A system of southwest-striking veins containing tourmaline, carbonate, and quartz may be related to a late stage of D_1 deformation. Generally less than 10 cm wide, the veins occur within the East Shore Plutonic Complex and the Lewis-Storey and Black Island assemblages, particularly in zones of high D_1 strain. The veins generally transect the S_1 foliation at a high angle and vein minerals, particularly tourmaline, commonly replace wall rocks along S_1 planes (Fig. 14). Observations linking the veins to D_1 deformation include mineralogy similar to that of the carbonate-quartz-chlorite assemblage in D_1 shear zones, local folding of veins by F_1 folds, and their orientation in an extensional field with respect to S_1 foliation.

Deformation D_2

The D_2 deformation is expressed throughout the area as open folds and crenulations in fissile zones and weak axial-plane foliation (S_2). The S_2 strikes southwesterly, with subvertical dips; F_2 fold hinges plunge moderately southwest and overprint earlier structures, including F_1 folds, at many localities (cf. Fig. 8, 10). The intensity of D_2 strain appears weak to modest throughout most of the area. However, in the southernmost exposures of the Black Island assemblage, D_2 shear zones overprinting S_1 fabrics may have accommodated significant transcurrent displacement. On islands north of Seymourville (Fig. 2), tight F_2 folds with angular hinges (Fig. 15) occur at the boundaries of a 10 m wide D_2 shear zone. Outcrop observations indicate that the shear fabric developed through transposition of S_1 foliation (Fig. 16). These islands are separated by water from exposures of Hole River arkose to the south that lack evidence of penetrative D_1 deformation.

Deformation D_3

The D_3 strain is most evident in the 1 km wide, east-trending, steeply dipping Seymourville shear zone, which marks the southern limit of the Hole River sedimentary sequence and accommodated approximately 7 km of dextral offset of the basal Lewis-Storey unconformity (Fig. 2).

Overprinting relationships between the chlorite-grade D_3 shear structures and older fabrics are evident at several locations within and adjacent to the Seymourville shear zone. In the southeast corner of the map area, northwest-trending D_1 shear zones can be traced into westerly trends through a zone of F_3 crenulation (Fig. 17). Within the shear zone, pods of quartz-carbonate-chlorite schist, characteristic of D_1 shear zones, display isoclinal F_3 Z-folds of S_1 layering. Near the southern margin of the zone, tonalite with northeast-trending S_2 foliation is transected by D_3 shear zones showing dextral deflection.

Although part of the linear nature of the zone results from re-orientation of older structures, a significant component is an S_3 shear fabric. This penetrative foliation and associated greenschist-facies protomylonite and mylonite zones dip steeply south (70°–85°) and are accompanied at high strain levels by a subhorizontal stretching lineation. A steep S_3 cleavage and associated F_3 folds are the dominant fabrics in the southern exposures of the Hole River sequence.

The poorly exposed region south of the Seymourville shear zone consists mainly of tonalitic rocks (Ermanovics, 1981). Observations of structures and overprinting relationships permit the definition of several structural domains

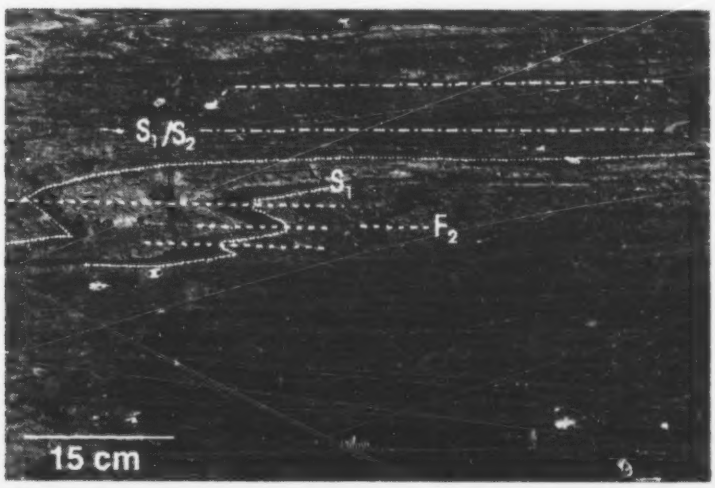

Figure 16.

D_2 shear zone developed through fold-limb transposition from highly D_1-strained basalt of the Black Island assemblage.

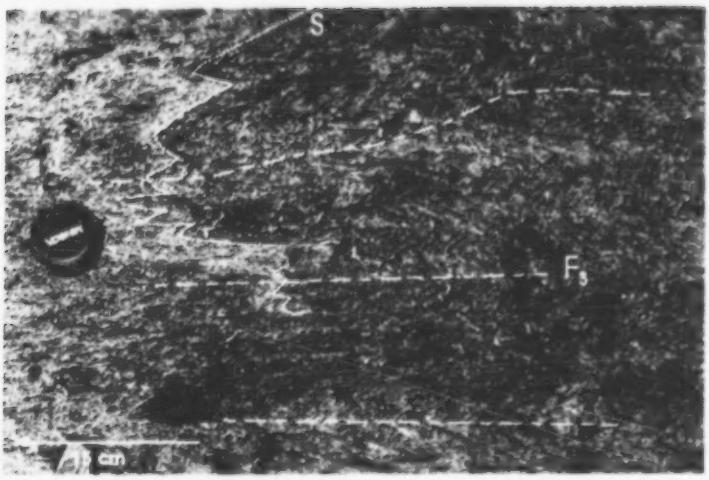

Figure 17.

Overprinting relationship in the Seymourville shear zone: F_3 folds overprint an early fabric (S), which may be S_1 or composite S_1–S_2 in chlorite-carbonate-quartz schist.

characterized by dominant D_1 and D_2 structures (Fig. 2). However, additional regional structural elements, not present north of the Seymourville shear zone, appear necessary to explain the structural geometry.

Other regional structures

At least two northwest-trending faults project into the area from the east and may bound structural domains south of the Seymourville shear zone. The dextral transcurrent Wanipigow Fault (Weber, 1991) separates the North Wanipigow assemblage and tonalite to the north, from metagreywacke to the south. The Beaver Creek Fault to the north juxtaposes the high-grade English Lake complex on the north from the low-grade Hay Creek serpentinite belt to the south (Poulsen et al., 1994). Although unexposed, these two structures project toward the Seymourville shear zone, but do not cut it, indicating pre-D_3 timing. The west-northwest trend of these faults is similar to that of D_1 shears, and the Wanipigow Fault has a structural geometry comparable to that of shear zones separating the Lewis-Storey and Hole River assemblages.

The northeast-striking English Lake shear zone separates the high-grade English Lake complex on the southeast from lower grade plutonic equivalents to the northwest (Percival and Whalen, 2000). Field observations of this moderately northwest-dipping ductile structure indicate sinistral and normal components, and map patterns suggest that it may offset the Wanipigow Fault and associated units. It is conjectural whether this structure is related to northeast-striking S_2 foliation north of the Seymourville shear zone.

SYN- TO POST-D_1 INTRUSIVE UNITS

In the northeastern part of the area, intrusions of both mafic and felsic composition cut units with S_1 fabrics. This includes up to 30 m wide, northeast-trending mafic dykes cutting units of the East Shore Plutonic Complex that contain prominent D_1 shear fabrics. The dykes carry a concordant, weak to moderate, internal foliation. The mafic dykes are cut locally by granitic dykes also bearing weak D_1 foliation and lineation. A suite of granodiorite dykes appears to preferentially intrude D_1 high-strain zones. A porphyritic variety cuts zones of amphibolite-facies deformation, whereas aplitic dykes are common in greenschist-facies shear zones. Both types cross-cut S_1 tectonic lamination, but are internally foliated and boudinaged. Concordant, map-scale sheets of medium- to coarse-grained biotite granodiorite are generally massive to weakly foliated or lineated and may postdate D_1 strain

DISCUSSION

Like the Conley Formation of the Wallace Lake belt (Sasseville and Tomlinson, 2000), the Lewis-Storey assemblage appears to represent a rift sequence built on 3 Ga crust of the North Caribou terrane. Tectonically juxtaposed mafic volcanic rocks are also a common feature, and the Gray Point sequence geochemically matches low-Th basalts of the Big Island assemblage, thought to represent an oceanic plateau setting (Sasseville and Tomlinson, 2000). No arc-like volcanic unit corresponding to the Drumming Point sequence occurs in the Wallace Lake belt, but coarse clastic assemblages may correlate, pending age data for the conglomeratic Siderock Lake assemblage. In both belts, D_1 structures are pervasive and disparate assemblages are juxtaposed along layer-parallel D_1 shear zones.

In the Rice Lake belt, neither basement nor rift sequences are exposed and the lowest stratigraphic unit is basalt of the Lower Bidou Lake Subgroup. Like the Gray Point sequence, these rocks are MORB-like, although they generally contain higher trace-element abundances and have positive primitive-mantle-normalized Th/Nb ratios. The upper Bidou Lake Subgroup consists of calc-alkalic basaltic andesite and dacite that may correlate with the Drumming Point sequence (Bailes and Percival, 2000a). Similarly, the coarse clastic

San Antonio Formation and Hole River assemblage have the same spectrum of detrital zircon ages (V. McNicoll and J. Percival, unpub. data, 2000).

Although these regional stratigraphic-lithogeochemical correlations are possible, reliable tectonic reconstruction of major lithotectonic domains is hindered by lack of exposure and the structural complexity in the Manigotagan Peninsula. Recognition and mapping of shear zones of at least three distinct ages and trends is a necessary step in deciphering the structural geometry, as well as in understanding regional linkages. In particular, D_1 shear zones, which may have accommodated major lateral transport, appear significant in <2.70 Ga dextral strike-slip juxtaposition of the oceanic Black Island assemblage with the North Caribou margin. However the continuity of these structures to the southeast is unconstrained. In addition to the younger faults, a complicating factor may be overlap in the age of D_1 deformation with the Hole River and equivalent sedimentary units. Geochronological work in progress will test the proposed structural framework, lithological correlations, and resultant tectonic interpretations.

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